BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates generally to propulsion and specifically to a method of producing propellant-less thrust using mass fluctuation.

PRIOR ART

Aerospace propulsion technology to date has rested firmly on simple applications of the reaction principle: Creating motion by expelling propellant mass from a vehicle. A peculiar, overlooked relativistic effect makes it possible to induce large, transient rest mass fluctuations in electrical circuit components [Woodward, J.F. (1990), "A New Experimental Approach to Mach's Principle and Relativistic Graviation [sic]" Found. Phys. Lett. 3, 497-506; (1992), "A Stationary Apparent Weight Shift from a Transient Machian Mass Fluctuation" Found. Phys. Lett. 5, 425-442]. An innovative implementation of this effect is to make engines that accelerate without the expulsion of any material whatsoever. This can be done because when the effect is combined with a pulsed thrust in appropriate circumstances, stationary forces can be produced [Woodward, J.F. (1992) "A Stationary Apparent Weight Shift from a Transient Machian Mass Fluctuation" Found. Phys. Lett. 5, 425-442; (1994), "Method for Transiently Altering the Mass of Objects to Facilitate their Transport of Change their Stationary Apparent Weights" U.S. Patent No. 5,280,864, U.S. GPO, 25 January; (1997b) "Mach's Principle and Impulse Engines: Toward a Viable Physics of Star Trek?" invited paper for the 1997 NASA "Breakthrough Propulsion Physics" workshop at the Lewis Research Center, 12-14 August]. "Impulse engines" are achieved without any moving parts (in the conventional sense). The concepts involved are supported by experimental results

1   already in hand. It is therefore desirable to create methods of configuring components

2   that optimize these devices and increase their practical utility.

3

4   The transient mass fluctuation effect upon which the method of this invention (and the

5   invention of U.S. Patent 5,280,864) depends is predicated upon two essentially

6   universally accepted assumptions. First, from general relativity theory: Inertial reaction

7   forces in objects subjected to accelerations are produced by the interaction of the

8   accelerated objects with a field (produced chiefly by the most distant matter in the

9   universe) -- they are not the immediate consequence of some inherent property of the

10   object alone. And second: Any acceptable physical theory must be locally Lorentz-

11   invariant; that is, in sufficiently small regions of space-time special relativity theory

12   (SRT) must obtain. Using standard techniques of physical and mathematical analysis,

13   these assumptions lead, for a particle of matter with rest mass density ρ_0 in a universe

14   like ours (with essentially constant matter density when considered at the large scale)

15   when accelerated by an external force, to the equation for the gravitation field potential

16   ϕ in terms of its local sources:

17

18

19

$$\nabla^2\phi - (1/c^2)(\partial^2\phi/\partial t^2) = 4\pi G\rho_0 + (\phi/\rho_0 c^2)(\partial^2\rho_0/\partial t^2) - (\phi/\rho_0 c^2)^2(\partial\rho_0/\partial t)^2 - c^{-4}(\partial\phi/\partial t)^2.$$

20

21   In this equation G is the Newtonian constant of universal gravitation, c is the vacuum

22   speed of light, and P_0 is the local rest-mass density. Details of the derivation of this

23   field equation can be found in Woodward, 1990, 1992, 1995, 1997a and 1997b

24   [Woodward, J.F. (1990), "A New Experimental Approach to Mach's Principle and

25   Relativistic Graviation [sic]" Found. Phys. Lett. 3 497-506; (1992), "A Stationary

26   Apparent Weight Shift from a Transient Machian Mass Fluctuation" Found. Phys. Lett.

27   5, 425-442; (1995), "Making the Universe Safe for Historians: Time Travel and the

28   Laws of Physics" Found. Phys. Lett. 8, 1-39; (1997a), "Twists of Fate: Can We Make

29   Traversable Wormholes in Spacetime?" Found. Phys. Lett. 10, 153-181; (1997b),

1 "Mach's Principle and Impulse Engines: Toward a Viable Physics of Star Trek?" invited

2 paper for the 1997 NASA "Breakthrough Propulsion Physics" workshop at the Lewis

3 Research Center, 12-14 August. The equation is at least approximately valid for all

4 relativistic theories of gravity.

5

6   In stationary circumstances, where all terms involving time derivatives vanish, the field

7 equation above reduces to Poisson's equation, and the solution for ϕ is just the sum of

8 the contributions to the potential due to all of the matter in the causally connected part

9 of the universe, that is, within the particle horizon. This turns out to be roughly GM/R,

10 where M is the mass of the universe and R is about c times the age of the universe.

11   Using reasonable values for M and R, GM/R is about c^2. In the time-dependent case

12 we must take account of the terms involving time derivatives on the right hand side of

13 this equation. Note that these terms either are, or in some circumstances can become,

14 negative. It is the fact that these terms can also be made very large in practicable

15 devices with extant technology that makes them of interest for rapid space time

16 transport, the chief area of application of impulse engines.

17

18   Since the predicted mass shift is transient, large effects can only be produced in very

19 rapidly changing proper matter (or energy) densities produced by accelerating matter.

20 From the point of view of detection of the effect, this means that the duration of any

21 substantial effect will be so short that it cannot be measured by usual weighing

22 techniques. If however, we drive a periodic mass fluctuation and couple it to a

23 synchronous pulsed thrust, it is possible to produce a measurable stationary effect

24 [Woodward, J.F. (1992), "A Stationary Apparent Weight Shift from a Transient Machian

25 Mass Fluctuation" Found. Phys. Lett. 5, 425-442; (1994), "Method for Transiently

26 Altering the Mass of Objects to Facilitate their Transport of Change their Stationary

27 Apparent Weights" U.S. Patent No. 5,280,864, U.S. GPO, 25 January; (1996b), "A

28 Laboratory Test of Mach's Principle and Strong-Field Relativistic Gravity" Found. Phys.

29 Lett. 9, 425-442]. Consider, for example, the generic apparatus shown in FIG. 1 in

1. which a stationary net force is produced by generating a periodic mass fluctuation in a

2. capacitor array (CA) and synchronously causing the length of a piezoelectric force

3. transducer (PZT) to oscillate so that the inertial reaction force of the accelerating CA on

4. the PZT and enclosure (E) is added to the weight of the assembly which is detected by

5. the depression of the steel diaphragm (D) measured by the position sensor (S), all of

6. which is located in a thick walled aluminum case © mounted on a seismically isolated

7. table. Here a mass fluctuation is produced in the CA by driving them with an AC

8. voltage. While the mass of the CA fluctuates, the PZT causes a synchronous,

9. oscillatory acceleration of the CA. The inertial reaction force F felt by the PZT [and the

10. enclosure (E) in which it is mounted] will be the product of the instantaneous mass of

11. the CA times the acceleration of the CA induced by the PZT. If the mass fluctuation

12. and acceleration are both sinusoidal and phase-locked at the same frequency, then

13. their product yields a phase-dependent, time-independent term -- a stationary force.

14.

15. The magnitude of this stationary force is calculated in detail in Woodward, 1992,

16. 1994, 1996b and 1997b. If we drive an oscillation in a PZT arranged like that in FIG. 1

17. with amplitude $\delta\ell_0$ at a frequency of 2ω, assume that the mass of the CA is small

18. compared to that of the enclosure E so that the excursion of the PZT accelerates the

19. CA only and allow for a phase angle δ between δm_0 and $\delta\ell_0$, the time averaged inertial

20. reaction force $<F> = \langle\delta m(t)\, a(t)\rangle$ detected by the sensor S (as a change in equilibrium

21. position due to the change in the force on the diaphragm spring D) is:

22.

23. $<F> = -2\omega^2\delta 1_0\delta m_0\cos\theta.$

24.

25. δm_0 is the amplitude of the mass fluctuation induced when a sinusoidal voltage of

26. angular frequency ω is applied to the capacitors. That is, the application of the voltage

27. to the capacitors leads to an instantaneous power $P = P_0\sin(2\omega t)$ in the circuit, leading

28. to a mass fluctuation:

29.

$$\delta m(t) \approx (\phi \omega P_0 / 2\pi G \rho_0 c^4)\cos(2\omega t) = \delta m_0 \cos(2wt).$$

The reality of the effect involved here and its implementation in producing stationary forces has been demonstrated in laboratory experiments [Woodward, 1996b, 1997b and below]. In this work $\delta \ell_0$ was a few angstroms (easily achieved with normal PZTs). When $P_0 \approx 250$ watts, $\omega \approx 8.8 \times 10^4$ (14 kHz), and $\cos\theta \approx \pm 1$, forces on the order of tens of dynes or more were produced in the apparatus. In practice one takes the difference between runs adjusted so that $\cos\theta \approx -1$. Results obtained at 14 kHz with a device of this sort are shown in FIG. 2. FIG. 2 displays the averaged results obtained with a device like that is shown in FIG. 1 where a capacitor array with a total capacitance of 0.02 microfarads mounted between piezoelectric transducers that produce an excursion of several hundred Angstroms was run at a power frequency of 28 kiloHertz during the time interval 7 to 12 seconds out of the 20 second data acquisition interval, resulting in a net force of about ninety five milligrams (dynes) when the data acquired for relative phases 180 degrees apart were differenced. The traces for the averages of the two phase settings are those that show large changes in the active interval. The heavy trace is that for 0 degrees of phase and the light trace that for 180 degrees of phase. The difference of these traces is the heavy trace that roughly vertically bisects the plot. These results were obtained with the case evacuated to a pressure of less than 15 mm of Hg. At 5 seconds into a data acquisition cycle the CA is powered up. In the 7 to 12 second interval both the CA and PZT are active. And at 14 seconds the CA is switched off. Typically one to two dozen such cycles are taken in a run with the phase θ switched back and forth by 180 degrees in alternating cycles of data. When the averages for the two phases are differenced, they produce the displayed differential weight shift. It is forces of the sort just described that can be used to make impulse engines.

SUMMARY OF THE INVENTION

The simplest impulse engine consists of electrical devices in which transient mass fluctuations can be induced by suitable electrical currents (capacitors with material dielectrics or inductors with material cores) affixed to force transducer(s) that produce the synchronous pulsed thrust needed to generate stationary forces on the object to which they are attached (likely a vehicle of some sort). A more efficient design employs two devices in which mass fluctuations are driven mounted on the ends of a force transducer, as in FIG. 3. FIG. 3 is a schematic illustration of the principle of the method of two element impulse engines, the elements in which the periodic mass fluctuations are driven being inductive L and capacitative C elements of a resonant circuit mounted on the ends of a force transducer that expands and contracts at the frequency of the mass fluctuations yielding a net force, and thus net motion, in the indicated direction when the phase of the mass fluctuation relative to the force transducer oscillation is that shown. When the mass fluctuations in the two devices are 180 degrees out of phase, the stationary forces produced by each device are in the same direction, doubling the output of the engine. This arrangement has the added advantage that the two devices can be made the capacitative and inductive components of a resonant circuit driven by a single power supply. A resonant circuit allows one to minimize the amount of external power required to drive the electrical oscillation in the circuit (after the circuit has been initially activated) that produces the mass fluctuations. Since the phase of the power flow in the capacitative and inductive elements differs by 180 degrees, the relative phase of the mass fluctuations automatically satisfy the requirement of an impulse engine. The relative phase of the mass fluctuations and the force transducer oscillations is then adjusted to maximize the stationary force produced by the engine.

7

1   The straight-forward elaborations of U.S. Patent 5,280,864 just discussed are all

2   predicated on the supposition that transient mass fluctuations are driven with

3   appropriate periodically varying (AC) electrical signals in discrete inductive or

4   capacitative circuit elements. Those circuit elements are then set into motion by a

5   separate, discrete force transducer, for example, a piezoelectric device or the

6   equivalent driven with a separate AC electrical signal [suitably phase-locked to the

7   power waveform of the signal driving the transient mass fluctuations in the other

8   discrete component(s)]. The crux of the invention here disclosed is to simplify systems

9   of this sort by using the force transducer(s) as the source of the motion needed to

10   produce the inertial reaction force(s) that cause the net thrust, and at the same time

11   drive the required mass fluctuation(s) in the same force transducer(s).

12

BRIEF DESCRIPTION OF THE DRAWINGS

1
2
3
4   The invention is described herein by reference to the scientific basis in observation,
5   theory, and experiment on which rests the full range of useful application of the
6   invention and by reference to the annexed drawings in which:
7
8   FIG. 1 is a schematic drawing of an apparatus in which a stationary net force is
9   produced by generating a periodic mass fluctuation in a capacitor array CA and
10   synchronously causing the length of a piezoelectric force transducer PZT to oscillate;
11
12   FIG. 2 displays the averaged results obtained with a device like that is shown in FIG.
13   1 where a capacitor array with a total capacitance of 0.02 microfarads mounted
14   between piezoelectric transducer that produce an excursion of several hundred
15   Angstroms was run at a power frequency of 29 kiloHertz during the time interval 7 to 12
16   seconds out of the 20 second data acquisition interval;
17
18   FIG. 3 is a schematic illustration of the principle of the method of two element impulse
19   engines;
20
21   FIG. 4 is a schematic diagram of a single active component impulse engine;
22
23   FIG. 5 is a schematic diagram of electrical circuitry required to generate the phase-
24   locked, phase adjustable electrical signals that produce the desired thrust;
25
26   FIG.6 is a longitudinal section diagram of a multiple active element impulse engine
27   employing two force transducers (FT) affixed to the ends of a rod (R);
28

9

1   FIG. 7a displays results obtained with the device that produced the results shown in

2   FIG. 2;

3

4   FIG. 7b displays the sensor oscillation amplitudes, obtained by rectifying and filtering

5   the AC coupled part of the total (AC and quasi-DC) sensor signal, corresponding to the

6   results shown in FIG. 7a;

7

8   FIG. 8 displays the results obtained with the device that produced the vacuum results

9   shown in FIG. 2, but with atmospheric pressure present in the case;

10

11   FIG. 9a displays the quasi-stationary force sensor traces and their difference obtained

12   with Device 1 operating with atmospheric pressure in the case;

13

14   FIG. 9b displays the quasi-stationary force sensor traces and their difference obtained

15   with Device 1 operating with the case evacuated;

16

17   FIG. 9c displays the oscillation amplitude traces and their difference that correspond

18   to the traces presented in FIG. 9a;

19

20   FIG. 10a displays the quasi-stationary force sensor traces and their difference

21   obtained with Device 2 operating with atmospheric pressure in the case;

22

23   FIG. 10b displays the quasi-stationary force sensor traces and their difference

24   obtained with Device 2 operating with the case evacuated;

25

26   FIG. 10c displays the oscillation amplitude traces and their difference that correspond

27   to the traces presented in FIG. 10a;

28

1   FIG. 10d displays the oscillation amplitude traces and their difference that correspond

2   to the traces presented in FIG. 10b;

3

4   FIG. 11a displays the quasi-stationary force sensor traces and their difference

5   obtained with Device 2 operating with a larger applied voltage to the PZT than that

6   used for FIG. 10 with atmospheric pressure in the case;

7

8   FIG. 11b displays the quasi-stationary force sensor traces and their difference

9   obtained with Device 2 operating with the case evacuated;

10

11   FIG. 11c displays the oscillation amplitude traces and their difference that correspond

12   to the traces presented in FIG. 11a;

13

14   FIG. 11d displays the oscillation amplitude traces and their difference that correspond

15   to the traces presented in FIG. 11b;

16

17   FIG. 12a displays the results obtained with a device similar to Device 2 run with the

18   apparatus oriented vertically (with atmospheric pressure in the case);

19

20   FIG. 12b displays the results obtained with the apparatus oriented horizontally

21   corresponding to those in FIG. 12a for vertical orientation;

22

23   FIG. 13 is a photo showing the device comprises of a stack of PZT disks clamped

24   between a brass base plate and an aluminum cap used to obtain the results presented

25   in FIGs. 13 and 14;

26

1   FIGs. 14a-14d present the component and summed waveforms (FIG. 14a and 14c),

2   used to excite the device shown in FIG. 13 yielding results (shown in FIG. 14b and 14d)

3   respectively at the 50 Watt power level; and

4

5   FIG. 15 displays the results obtained with the device shown in FIG. 13 run at higher

6   power (about 100 Watts).

7

DETAILED DESCRIPTION OF THE INVENTION

Force transducers come in a variety of forms. We shall be interested in those where time varying electromagnetic fields are applied to material cores. Capacitive transducers of this sort are exemplified by (but not limited to) piezoelectric devices; and inductive transducers are exemplified by (but not limited to) solenoidal devices. In both cases, when a time varying electromagnetic field is applied to these devices, energy is stored in the dielectric or magnetizable cores by the polarization of the material. Such polarization induces the acceleration of the constituents of the core material and accordingly a transient mass fluctuation ensues in the core. When a periodic, say sinusoidal, electromagnetic field is applied to one of these devices at some well defined frequency ω, a transient mass fluctuation with frequency 2ω is driven in the core material. Since the frequency of the mass fluctuation is twice the frequency of the signal driving the excursion of the transducer, no stationary thrust is generated in the transducer by the interaction of the mass fluctuation with the excursion at the fundamental frequency. (That is the reason why the devices we have explored to this point have been designed with components where the mass fluctuations and mechanical excursions were generated in discrete components).

If, however, the driving signal excited a second harmonic excursion in a force transducer (through, for example, electrostriction in the case of a piezoelectric device), then the interaction of this excursion with the induced mass fluctuation will produce a net thrust if the phase relationship of the mass fluctuation and second harmonic excursion is such that $\cos\theta$ for <F> in the above expression is not equal to zero. Since the mass fluctuation is phase-locked with respect to the driving signal, the relative phase of the second harmonic excursion and mass fluctuation cannot be simply adjusted. So, while the amplitude of such an effect can be adjusted by changing the amplitude of the driving signal, it cannot be explored by adjustment of the relative

13

1 phase of the excursion and mass fluctuation. And such an effect, if present in a given

2 transducer, might be far smaller than possible because cosθ might be inadjustably

3 close to zero. Similarly, because a single frequency driving signal is used, the relative

4 amplitudes of the second harmonic excursion and mass fluctuation cannot be adjusted.

5

6 The key aspect of the method of this invention is that a mass fluctuation may be

7 driven in a force transducer by applying an electromagnetic signal of one particular

8 frequency and at the same time an excursion that takes place at the frequency of the

9 mass fluctuation needed to produce a stationary thrust can be induced by applying

10 another electromagnetic signal at twice the frequency of the first to the transducer with

11 suitable (and adjustable) relative phase and amplitude. This may be achieved, for

12 example, by applying an AC electrical voltage signal to the force transducer(s) that

13 consists of the sum of two (or more) simple sinusoidal waveforms, (at least) one being

14 twice the frequency of the other and suitably phase-locked to the power (voltage times

15 current) waveform that results from the lower frequency signal. (In optimized devices

16 waveforms with more than two simple sinusoidal wave components may prove

17 desirable). The transducer(s) to which such complex waveforms are delivered is (are)

18 then affixed to the device upon which the generated thrust is to be exerted in such a

19 way that the transducer and mounting apparatus are strongly mechanically resonant at

20 the higher of the two frequencies, but not resonant at the lower of the two frequencies.

21

22 As a purely illustrative, non-limiting example of this method, consider the simplest

23 possible system of this sort shown in FIG. 4. A force transducer (FT, for example, one

24 (or more) piezoelectric crystal disk(s)) is affixed to a short, rigid, elastic rod (R), which

25 is in turn affixed to some massive object (MO, for example, some device such as a

26 vehicle) upon which the thrust generated in the FT and R is to act. The physical

27 properties and dimensions of the FT and R are chosen so that the lowest frequency

28 mechanical resonance in the FT and R along the vertical axis in FIG. 4 that passes

29 through the FT and R occurs at the higher of the two voltage frequencies used to excite

14

1   the FT. (To optimize this device, the dimensions of the FT and R should also be

2   chosen so that only the mechanical extension mode in them is excited at this

3   frequency. That way energy is not sinked into oscillatory modes that do not contribute

4   to the generated thrust). So disposed, only a very modest voltage signal at the

5   mechanical resonance frequency need be applied to produce large excursions of the

6   FT.

7

8   In order to generate the thrust in the system FT/R/MO, all that needs to be done is to

9   apply a very large voltage signal, tuned to half the mechanical resonance frequency, to

10   the FT. Since the mechanical resonance frequency is designed to be the lowest

11   frequency mode of oscillation, this large voltage signal will nct drive a strong

12   mechanical oscillation in the device, notwithstanding that a strong piezoelectric

13   response can be expected in the FT. But the fluctuating power will induce a large

14   oscillatory transient mass fluctuation in the FT at twice the frequency of the applied

15   voltage signal. The resulting mass fluctuation, being at the mechanical resonance

16   frequency of the FT and R, if large enough, may be expected to excite a mechanical

17   oscillation at that frequency. The resulting mechanical oscillation will be phase-locked

18   to the power waveform of the low frequency component of the voltage signal.

19   Depending on the details of the dimensions of the device that determine the phase

20   relationship between the mass fluctuation and the mechanical excursion it excites, the

21   application of the low frequency voltage signal to the FT and R may, or may not, result

22   in the production of a stationary thrust on the MO.

23

24   To insure that a steady thrust is generated in the FT and R and to facilitate its control,

25   a voltage signal at the mechanical resonance frequency is applied to the FT

26   simultaneously with the low frequency voltage signal that induces the transient mass

27   fluctuation in the FT. While the high frequency voltage signal must be phase-locked to

28   the power waveform of the low frequency voltage signal, their relative phase can be

29   easily adjusted by conventional electronic circuitry (i.e., "phase shifters"). Accordingly,

15

1   the phase of the mechanical oscillation (controlled by the high frequency voltage

2   signal) and the transient mass fluctuation (controlled by the low frequency voltage

3   signal) can be manipulated to maximize, minimize or reverse the thrust applied to the

4   MO by a simple phase adjustment of the two voltage signals before they are summed.

5   (The amount of thrust generated can also be controlled by adjusting the amplitude(s) of

6   the voltage signal(s) delivered to the FT). A block diagram of generic electronic

7   circuitry that, in conjunction with a generic device like that of FIG. 4, will achieve this

8   performance is shown in FIG. 5. FIG. 5 is a schematic diagram of the chief electrical

9   circuitry required to generate the phase-locked, phase adjustable electrical signals that,

10 combined in a summing amplifier and then further amplified in a power amplifier, are

11 applied to the FT of FIG. 4 produce the desired thrust. Since the devices driven

12 operate at or near mechanical resonance, the signal generator must be stable to about

13 a part in one hundred thousand. The output of the frequency doubler must likewise be

14 stable and free from any low frequency modulation.

15

16 With careful design, the various energy losses that occur in any realization of this

17 method, all of which may be expected to ultimately be thermalized, can be minimized,

18 but they cannot be entirely eliminated. Since the materials used to make force

19 transducers are temperature sensitive, their performance being sharply and often

20 irreparably degraded by elevated temperatures, provision must be made for adequate

21 cooling of impulse engines. This may be achieved in several ways. For example, if the

22 engines must operate in vacuum, then Peltier junction devices can be applied to them.

23 But in most circumstances vacuum operation should not prove necessary. For even in

24 a vehicle in the vacuum of outer space, since no propellant is expelled by impulse

25 engines, they can be located anywhere within a craft and cooled by a suitable transfer

26 fluid that carries the heat to convenient radiators mounted on the exterior of the craft.

27

1   The method disclosed here in the simplest of circumstances can be further articulated

2   and optimized in a number of ways. We give two purely illustrative and non-limiting

3   examples of such optimizations/articulations. First, the force transducer(s) should be

4   made part(s) of electrically resonant circuits by the addition of properly tuned inductive

5   or capacitative circuit elements and resistive losses in the(se) circuit(s) should be

6   minimized. These steps will reduce both waste heat generated and the power required

7   to run the engine. (The electrical resonance frequency should be that for the low

8   frequency voltage signal since the high frequency signal is the second harmonic of that

9   signal and will automatically be resonant).

10

11   Second the "dumbbell" configuration of FIG. 3 can be used with modification. In

12   particular, the inductive and capacitative circuit elements in which transient mass

13   fluctuations are driven in that configuration can be replaced by force transducers driven

14   by the multiple frequency waveforms of the present method, and the force transducer

15   located between the now force transducers on the ends can be eliminated, as in FIG. 6.

16   FIG. 6 is a longitudinal section diagram of a multiple active element impulse engine

17   employing two force transducers(FT) affixed to the ends of a rod (R) which when

18   excited by the high frequency signals applied to the transducers causes the transducer

19   to undergo accelerations that produce a net force because of the transient mass

20   fluctuation caused in the transducer by low frequency voltage signals with appropriately

21   adjusted phases so that the mass fluctuations are 180 degrees out of phase. Also

22   shown is a mid-point mount connecting the engine to the massive object (MO) to be

23   acted upon. The mechanical structure between the force transducers becomes the

24   resonant rod of FIG. 4, attached at its mid-point to the massive object to which the

25   thrust is to be applied. The mass fluctuations in the two force transducers are adjusted

26   to be 180 degrees out of phase and electrically resonant circuits are used to optimize a

27   device of this sort.

28

EMPIRICAL CONSIDERATIONS

Evidence that the method here disclosed can be applied to practical scale situations is present in the results shown in FIG. 2. The device used to obtain these results was one with a separate CA and PZT. The experimental protocol employed to obtain the results was the differencing of cycles of data taken with the phase of the CA power waveform, initially fixed with respect to the PZT oscillation waveform, switched between the initial setting and one that differed by 180 degrees. This subtraction method permitted the elimination of systematic effects and errors that were insensitive to the relative phase of the CA and PZT. One of those systematic effects removed by this protocol was the obvious change in the force (in this case weight) registered by the force sensor when the PZT was switched on, plainly present for both phases in FIG. 2. This behavior is made plain in FIG. 7a where results are shown for two power levels of a simple sinusoidal voltage applied to the PZT in this device (that is, the CA was not activated at all). (Indeed, investigation of the origin of this systematic effect contributed to the conceptualization of the method here disclosed.) FIG. 7a displays results obtained with the device that produced the results shown in FIG. 2. Here, however, the capacitor array (CA) was not activated and the two traces that are differenced were produced by changing the amplitude of the voltage signal driving the PZT. Those amplitudes were chosen so that the behavior approximately mimicked the results shown in FIG. 2.

Setting aside the cause of the force produced when the PZT was activated, the sort of scalling one might expect is seen to be present. The larger the amplitude of the voltage signal, the larger the magnitude of the effect seen. And the larger should be the amplitude of the force sensor oscillations. The rectified AC coupled force sensor signals corresponding to the traces in FIG. 7a are displayed in FIG. 7b. FIG. 7b displays the sensor oscillation amplitudes, obtained by rectifying and filtering the AC coupled part of the total (AC and quasi-DC) sensor signal, corresponding to the results

1   shown in FIG. 7a. Note that the zero-phase (heavy trace) quasi-DC signal corresponds

2   to the larger oscillation amplitude, as expected if the effect scales with the power

3   applied and the response of the spring diaphragm (D in FIG. 1) is approximately linear.

4   (AC coupling removes any DC component of the signal, that is, any stationary force, so

5   the rectified AC signal is proportional to the amplitude of mechanical oscillation of the

6   sensor induced by the operation of the device. The sensor oscillation amplitude

7   signals were not absolutely calibrated, so they are only identified as "oscillation units".

8   These units, among the various results presented here, however, are always the

9   same). As one would expect, the sensor oscillation amplitude is larger for the higher

10   voltage signal delivered to the PZT. But the question remains: Are the observed effects

11   produced by transient mass fluctuations coupled to mechanical excursions of parts of

12   the apparatus? Or are they actually attributable to conventional sources?

13

14

15   **THE REALITY OF TRANSIENT MASS FLUCTUATIONS**

16

17   Inquiring into the cause of the forces recorded in FIG. 7a reveals three possibilities.

18   They are: 1) Thrusts originating in acoustical coupling of the device to the enclosing

19   case in which it resides; 2) Non-linear response of the force transducer, especially the

20   diaphragm spring; and 3) A genuine effect. Other sources of spurious effects are ruled

21   out by the protocols described in Woodward, 1996b and 1997b. Among those

22   protocols one is particularly important; the shorting out of the CA and the placement of

23   an equal capacitance elsewhere in the circuit so that all of the normal running

24   conditions could be mimicked without inducing the mass fluctuation in the CA. When

25   this was done, the differential effect in FIG. 2 disappeared as expected. (The

26   stationary thrusts produced by activation of the PZT, however, were still present [and

27   equal]).

28

1   Acoustical coupling effects are easily excluded as the source of the forces by

2   evacuating the enclosing case, thus removing the bulk of the coupling medium.

3   Indeed, the results displayed in FIGs. 2, 7 and 8 were all obtained with a case pressure

4   of less than 15 mm. of Hg. The results shown in FIG. 2 differ insignificantly from those

5   obtained at atmospheric pressure, in otherwise identical circumstances, presented in

6   FIG. 8. FIG. 8 displays the results obtained with the device that produced the vacuum

7   results shown in FIG. 2, but with atmospheric pressure present in the case. Since the

8   results for vacuum and atmospheric pressure differ insignificantly, it follows that the

9   differential effects present in both instances cannot be attributed to acoustic coupling of

10   the parts of the device to the rest of the apparatus. It follows that although acoustic

11   coupling might be important in some apparatuses, in this apparatus, run under these

12   conditions, it is not. The cause of both the differential thrust effect and the effect

13   proper to the PZT must be sought elsewhere. Non-linear behavior of some sort is a

14   likely candidate, for non-linearly coupled systems can produce unusual behavior. In

15   the case of this apparatus, however, such non-linearity must occur in the force sensor,

16   for non-linear behavior elsewhere in the system, by the conservation of momentum,

17   cannot generate net thrusts.

18

19   When oscillatory motion is present, spring non-linearity can produce spurious force

20   signals that might be mistaken for a genuine effect. Non-linearity effectively means that

21   the spring constant ceases to be a constant and becomes a function of the distance

22   through which the spring is compressed. Consequently, the mean position of the end

23   of the loaded spring when in oscillation is not the same as that for simple static loading.

24   Moreover, the mean position will be a function of the amplitude of the oscillation. For a

25   linear spring the static and oscillatory mean positions are the same (irrespective of the

26   amplitude of any oscillation). Other non-linear effects (for example, oscillatory

27   displacement of the magnetoresistive elements of the force sensor from the region of

28   the sense magnetic field where their response is linear) will also result in effects

29   proportional to the amplitude of the driven oscillation. (The basic linearity of the

20

1   position sensor and the bridge circuit used were more than adequate). As shown in

2   FIG. 7b, activation of the PZT does induce an oscillation in the spring; one that is

3   proportional to the amplitude of the voltage applied to the PZT. The question to be

4   answered is: Does the resulting thrust detected, and its change with the applied voltage

5   amplitude, arise from spring (or other) non-linearity in the force sensor, or a genuine

6   mass fluctuation effect coupled to a second harmonic excursion induced in the PZT?

7

8   The answer to the question sought here is provided by inspecting the behavior of the

9   oscillation amplitudes corresponding to the differential effects produced in air and

10   vacuum for devices of the type already described. This is possible because the spring

11   diaphragm of the force sensor responds to oscillations differently in vacuum as

12   opposed to air. But in both air and vacuum its response to stationary forces remains

13   the same. This behavior is a consequence of the normally sealed diaphragm having

14   two No. 70 AWG holes drilled in its periphery to allow the interior and exterior

15   pressures to equalize when the case is evacuated. The holes are so small that

16   although pressure equalization takes place with a time constant of a second or so, for

17   oscillations at frequencies of tens of kiloHertz, when air is present in the diaphragm it is

18   unable to flow through the holes quickly enough to equalize as the oscillation proceeds.

19   As a result, the air acts as a supplementary spring, changing the oscillatory response

20   of the force sensor (from that in a vacuum) while leaving the response to quasi-

21   stationary forces unchanged. Consequently, if the differential effects seen arise from

22   non-linearities in the force sensor, then they should change in proportion to the change

23   in the oscillatory behavior of the force sensor when the system is run in air and

24   vacuum.

25

1   To demonstrate that force sensor non-linearities do not contaminate the results that

2   show the presence of the mass fluctuation effect, we present data obtained with two

3   different devices run in both air and vacuum in otherwise identical circumstances. The

4   data for Device 1 is displayed in FIGs. 9a, 9b, 9c and 9d. FIGs. 9a and 9b show the

5   quasi-stationary response in air and vacuum respectively. FIG. 9c presents the (AC

6   coupled) force sensor oscillation amplitude that corresponds to panel A, and panel D

7   the oscillation amplitude corresponding to panel B. Inspection of FIGs. 9c and 9d

8   reveals that when the CA was switched on at 5 seconds into the cycles, a small

9   oscillation was set up in the spring. (The deviation from the initial quiescent state was

10   in opposite directions for the two phases because the reference signal for the lockin

11   amplifier that rectifies these signals is the source voltage signal for the PZT which did

12   not change when the relative phase of the PZT and CA power waveforms were shifted

13   by 180 degrees). When the PZT was switched on at 7 seconds and additional, much

14   larger oscillation was set up in the spring.

15

16   Comparing the total oscillation amplitudes (with both the CA and PZT on) in FIGs. 9c

17   and 9d, we see that the amplitude in vacuum (FIG. 9d) is smaller than that in air (FIG.

18   9c) by about 40 percent, as expected. Comparison of the differential quasi-stationary

19   forces in FIGs. 9a and 9b (the heavy traces that roughly bisect the diagrams) should

20   reflect this behavior if force sensor non-linearities are their cause. But the measured

21   differential effect in vacuum (FIG. 9b) is about 20 percent larger, rather than 40 percent

22   smaller, than the effect in air (FIG. 9a). This is precisely the opposite of expectation on

23   the force sensor non-linearities hypothesis. (The larger quasi-stationary effect in

24   vacuum can be accounted for by the excursion of the CA/PZT assembly not being

25   damped by the presence of air in the case).

26

1   The conclusion that force sensor non-linearities are not the cause of the differential

2   quasi-stationary signals seen in FIGs. 9a-d are corroborated by results obtained with a

3   second, similar device. When run in approximately comparable circumstances, the

4   results displayed in FIGs. 10a, 10b, 10c and 10d were obtained. The details differ from

5   FIGs. 9a-9d. There is a 30 percent decrease in oscillation amplitude in vacuum instead

6   of 40 percent. And there is only a 5 percent increase in the quasi-stationary differential

7   effect in vacuum rather than 20 percent. But the basic behavior remains inconsistent

8   with the force sensor non-linearities hypothesis. This is yet more starkly apparent in

9   FIGs. 11a-11d, the counterpart of FIGs. 10a-10d for a higher power signal applied to

10   the PZT with this device. Here the oscillation amplitude decrease in vacuum is about

11   70 percent rather than 30 or 40 percent. Yet the differential quasi-stationary forces in

12   both air and vacuum are about 100 milligrams (dynes).

13

14   Further corroboration of the conclusion that force sensor non-linearities are not the

15   cause of the differential quasi-stationary forces detected can be found in the details of

16   the data presented in FIGs. 9-11. For example, in FIG. 9d (Device 1) the differential

17   oscillation amplitude trace (that roughly bisects the panel) reveals that when both the

18   CA and PZT were activated, the total oscillation amplitudes for the two phases were

19   essentially identical. This, on the non-linearities hypothesis, requires that no

20   differential quasi-stationary force effect be present in FIG. 9b, but the effect is there

21   nonetheless. Similarly, in FIG. 11d (Device 2, high power) we find that the smaller

22   oscillation amplitude (heavy trace) corresponds to the larger quasi-stationary effect

23   (heavy trace) in FIG. 11b. This is precisely the opposite of expectation on the non-

24   linearities hypothesis. So the conclusion that the quasi-stationary effect is not due to

25   force sensor non-linearities is warranted. Since no other spurious effect accounts for

26   the observed effect, by exclusion we may infer that it arises from transient mass

27   fluctuations.

28

1   Another test of the genuiness of the stationary force effect can be conducted by

2   running the apparatus in a horizontal orientation and comparing the results obtained

3   with those produced when the apparatus is run in its normal vertical orientation.

4   Should the effect depend on some subtle coupling to local objects, one would expect

5   the measured effect to change. But if the effect is genuine, it should be independent of

6   the local orientation of the apparatus since the mass fluctuation effect is generated by

7   an interaction with the uniformly distributed distant matter in the universe. The results

8   of such a test (for yet another device than those mentioned so far similar to Device 2)

9   are displayed in FIGs. 12a and 12b. The magnitude of the differential effect is

10 essentially the same for both orientations, corroborating the predicated orientation

11 . independence.

12

13

14 **PRACTICAL DEMONSTRATION OF THE METHOD**

15

16 Force transducers, PZTs in particular, activated by complex waveforms as disclosed

17 here, should produce thrusts as described above. The device shown in FIG. 13 was

18 constructed to demonstrate the feasibility of the disclosed method. The device consists

19 of a stack of PZT disks 0.75 inches in diameter by about 0.75 inches thickness

20 mounted on a brass plate (that is bolted to the weighing suspension of the device

21 depicted schematically in FIG. 1). To avoid thermal degradation of the mechanical

22 performance of the PZT, it is clamped to the brass plate with an aluminum disk and six

23 machine screws. Power is delivered to the PZT via a twisted pair of stranded 26 AWG

24 copper wires. The resonant rod (R) of FIG. 4 is the suspension that connects the PZT

25 assembly with the spring diaphragm located in the bottom of the case. The case

26 corresponds to the massive object (MO) of FIG. 4.

27

1 The voltage waveforms that were applied to the device shown in FIG. 13 and

2 produced large effects, are displayed in FIG. 14 along with the differential forces

3 produced when the power used was about 50 Watts. Typically, the amplitude of the

4 high frequency component of the signal was a fifth or less of the amplitude of the low

5 frequency component (as shown). Since the power in each frequency component is

6 proportional to the square of the voltage amplitude, almost all of the power delivered to

7 the PZT went into the low frequency component driving the mass fluctuation. Results

8 obtained when the device was driven with a signal of roughly 100 watts power are

9 presented in FIG. 15. The low frequency, high power component of the voltage signal

10 that drives the transient mass fluctuation in the PZT was activated at 5 seconds in each

11 data cycle. At 7 seconds into each data cycle the high frequency, low power

12 component of the voltage signal was switched on. The voltage waveform used was that

13 in FIG. 14a. (The sequence of phase alternation here, however, was reversed, so the

14 differential trace is inverted with respect to that in FIG. 14b). Differential thrusts of

15 about 400 dynes (0.4 grams) were produced at this modest power level. With

16 optimization and appropriate scaling one should be able to significantly increase the

17 thrusts.

18

19

20 **FURTHER CONSIDERATIONS RELATING TO THE METHOD**

21

22 In an ideal impulse engine the circuits containing the fluctuating mass element(s) and

23 the force transducer(s) would be completely lossless. That is, in a two element engine

24 like that shown in FIG. 3, the LC circuit would be superconducting and the cores of the

25 L and C would not thermalize any of the energy periodically transiently stored in them.

26 Thus, once activated, the energy flow in this circuit that produces the mass fluctuations,

27 would continue indefinitely without attenuation. (Since this will not be true in a real

28 engine, as mentioned above, provision must be made for the disposal of waste heat).

29 Likewise, an ideal force transducer, once activated, like a lossless spring, should

1   continue to oscillate with constant amplitude forever, notwithstanding that the mass(es)

2   on its end(s) may be fluctuating periodically. (As with the LC circuit, since ideal

3   behavior can at best only be approximated, losses may be expected, resulting in waste

4   heat that will have to be disposed of).

5

6   The ideal, completely lossless impulse engine reveals an issue that should be

7   addressed: Once activated, an ideal impulse engine will continue to produce an

8   accelerating force without diminution of the activating energy and therefore without the

9   need of continuing delivery of energy to the engine from local sources. Viewed locally,

10   the engine seems to violate both the conservation of momentum and energy because it

11   can cause the acceleration both of itself and any unconstrained massive body to which

12   it may be attached. (Note that such violations do not occur in an engine where the

13   fluctuation of the masses of the elements on the ends of the force transducer are

14   effected by the transport of some mass back and forth between the elements. In this

15   case the inertial reaction produced by the mass transport precisely compensate the

16   forces that would otherwise produce impulse engine behavior).

17

18   Impulse engines work because the mass fluctuations in the inductive and/or

19   capacitative components do not depend on the passing of mass back and forth

20   between them. Rather, the origin of the mass fluctuations in each of the elements

21   (notwithstanding that they may be electrically coupled) is in a field interaction with

22   chiefly the most distant matter in the universe. This is apparent from the fact that the

23   transient source terms (in the field equation presented above) that account for the

24   mass fluctuations arise from the interaction between accelerated local objects and the

25   field that causes inertial reaction forces. That field is the gravitational interaction with

26   cosmic matter. Various considerations [Woodward, J.F. (1996a),"Killing Time" Found.

27   Phys. Lett. 9, 1-23] suggest that the momentum and energy transfer conveyed by this

28   field involved in impulse engines take place as retarded and advanced effects traveling

29   at the speed of light along the future lightcone [Woodward, 1997b]. The presence of

1   advanced effects (that propagate backward in time) make the transfer appear

2   instantaneous. In effect, an impulse engine pushes off the matter located along the

3   future lightcone through an inertial/gravitational interaction. In so doing, positive

4   energy and momentum flow backward in time along the future lightcone to the engine.

5

6   A few technical details, critical to the successful implementation of the method here

7   disclosed, deserve mention. First, since the method only works when all of the forces

8   generated in the engine behave as described above, ensuring as nearly ideal, rigid

9   mechanical contact between the various components of the engine is essential.

10   Particularly important in this connection is the sparing and very careful use of

11   adhesives. They can easily degrade mechanical joints and produce serious acoustic

12   impedance mismatches that can compromise engine efficiency. For this reason,

13   whenever possible mechanical fasteners should be used. Second, since the mass

14   fluctuation effect scales with the frequency of the applied voltage signal, operation at

15   high frequency is desirable. When the operation frequency exceeds five kiloHertz in

16   engines more than several centimeters in length, however, acoustic waves reflected in

17   the engine (and objects to which the engine is attached) may interfere with the primary

18   engine excitations and degrade, perhaps dramatically, engine performance.

19   Accordingly, the engine (and any object to which it is attached) must be designed to

20   minimize unwanted reflected sound waves. This may be accomplished by using

21   surfaces that greatly attenuate acoustic energy reflections or by shaping surfaces to

22   reflect acoustic energy in a selected direction which precludes interference with primary

23   engine excitations.

24

25   Having thus disclosed a detailed description of a method and apparatus of the

26   invention, it being understood that the disclosure herein is of exemplary preferred

27   embodiments that are not necessarily limiting of the scope of protection afforded

28   hereby, what we claim is:

29